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Assessing direct contributions of morphological awareness and prosodic sensitivity to
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Abstract

We examined the independent contributions of prosodic sensitivity and morphological awareness to word reading, text reading accuracy, and reading comprehension. We did so in a longitudinal study of English-speaking children ($N = 70$). At 5 to 7 years of age, children completed the metalinguistic measures along with control measures of phonological awareness and vocabulary. Children completed the reading measures two years later. Morphological awareness, but not prosodic sensitivity made a significant independent contribution to word reading, text reading accuracy and reading comprehension. The effects of morphological awareness on reading comprehension remained after controls for word reading. These results suggest that morphological awareness needs to be considered seriously in models of reading development and that prosodic sensitivity might have primarily indirect relations to reading outcomes.

Keywords: *Morphological Awareness; Prosody; Word Reading; Reading Comprehension.*

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Assessing direct contributions of morphological awareness and prosodic sensitivity to children's word reading and reading comprehension.

Learning to read involves working out how spoken language is mapped onto written form (Nagy, 2007). Empirical research has established awareness of segmental phonology as key in learning to decode words (e.g., NICHD, 2000). Awareness of other components of oral language might become important as children encounter more complex words and texts (e.g., Demont & Gombert, 1996; Nagy & Anderson, 1984). Consider *artistic*. It includes three morphemes (*art* + *ist* + *ic*) and a complex stress pattern (Weak-Strong-Weak). These are both separable and related features (e.g., Jarmulowicz, Taran, & Hay, 2007); adding the suffix *-ic* changes the noun to an adverb and shifts stress to the second syllable. Awareness of each of these features, or morphological awareness and prosodic sensitivity respectively, has been linked to reading outcomes (e.g., Carlisle, 2000; Whalley & Hansen, 2006). Little empirical work has evaluated their potentially separable effects on word reading and reading comprehension; this is our focus.

In terms of word reading, there are several reasons to suspect that separable contributions of each of morphological awareness and prosodic sensitivity. Morphological awareness might support word reading by helping children choose pronunciations for individual words; for example, the morphemic boundaries in *reading* and *react* determine the differing pronunciations of *ea*. The semantic weight of morphemes might lead to unique effects (Keenan & Betjemann, 2008). And yet, with most new words that children encounter in texts containing multiple morphemes (e.g., Nagy & Anderson, 1984), they are also multi-syllabic (Baayen, Pipendrock, & Gulikers, 1993) and require stress assignment for reading aloud. Some, but not all letter-patterns marking stress are morphemes (Arciuli, Rankine, & Monaghan, 2010), suggesting that sensitivity to prosodic features of language might have specific effects on word reading.

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Most research to date on these relations to word reading has examined indirect links (e.g., Kim & Petscher, 2016); two studies, both with 5- and 6-year-old children, examine direct connections. In one, modelling pointed to direct relations to word reading for morphological awareness, but not prosodic sensitivity (Holliman et al., 2014). In a second, there were direct effects of each of prosodic sensitivity and morphological awareness to word reading, after controlling for phonological awareness and vocabulary (Holliman et al., 2017). Results from these studies with young readers point to potential direct relations for morphological awareness with word reading, with mixed evidence for prosodic sensitivity.

There are also reasons to suspect direct relations of each of morphological awareness and prosodic sensitivity to reading comprehension. Indeed, reading with accurate prosody is related to success in reading comprehension (e.g., Miller & Schwanenflugel, 2004, 2008). And yet reading aloud with accurate prosody likely draws on both prosodic sensitivity and word and text level reading skills. In terms of morphological awareness, some argue that it impacts reading comprehension because it integrates syntactic, semantic, and phonological dimensions of the linguistic system (e.g., Deacon, Kieffer, & Laroche, 2014). This linguistic basis for a link to reading comprehension might or might not overlap with that of prosody.

Despite extensive separate investigation (e.g., Carlisle, 1995; Whalley & Hansen, 2006, there has been little exploration to date of potential direct relations from each of prosodic sensitivity and morphological awareness to reading comprehension. Clin et al. (2009) found that each of prosodic sensitivity and morphological awareness were significantly related to a composite score across word reading and reading comprehension. Performance on the stress-changing, but not stress-neutral items in the morphological awareness task was uniquely related to reading outcomes, likely capturing awareness of both morphemes and prosody. As such, it is not clear whether there are direct unique relations between each of prosodic sensitivity and morphological awareness and reading comprehension.

The Present Study

We examined the unique effects of each of morphological awareness and prosodic sensitivity on word reading and reading comprehension. We assessed vocabulary and phonological awareness to isolate effects from known contributors to reading outcomes (e.g., NICHD, 2000; Verhoeven & Van Leeuwe, 2008). Our prosodic sensitivity task tapped multiple aspects of prosody relevant to both word- and text-level reading. To isolate morphological effects, we assessed morphological awareness with stress neutral suffixes only (following Holliman et al., 2014). We included standardised measures of both word reading and reading comprehension. Predictors were assessed at ages 5 or 6 years, and word reading and reading comprehension at 8 or 9 years of age. This is an age at which word reading and reading comprehension clearly diverge (e.g., Gough, Hoover, & Peterson, 1996) and texts include many morphologically complex multisyllabic words (e.g., Nagy & Anderson, 1984).

Theories make competing predictions. The Simple View of Reading (Gough & Tunmer, 1986) would predict no unique effects of either morphological awareness or prosodic sensitivity, instead focusing on joint contributions across language. In contrast, the Reading Systems Framework suggests unique direct effects of morphological awareness on both word reading and reading comprehension (Perfetti & Stafura, 2014). Connectionist approaches would point to direct effects of both morphological awareness and prosodic sensitivity on word reading (Arciuli, Monaghan, & Seva, 2010; see also Seva, Monaghan, & Arciuli, 2009). Intriguingly, a recent model of prosodic sensitivity does not include direct effects (Wood, Wade-Woolley, & Holliman, 2009). Empirical work would help disentangle these competing views.

Method

Participants

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Participants were originally recruited in Year 1 or 2 for Holliman et al. (2014), at an average age of 6 years and 2 months. Participating children were all from a large primary school in the United Kingdom. Relative to other similar schools in the UK, this school had fewer children who spoke English as an additional language and who were eligible for free school meals (<http://www.education.gov.uk/schools/performance/>). Following on an initial consent rate of 80%, there was 6.7% attrition to Years 3 and 4, all due to moving schools. In Years 3 and 4, a total of 70 children (37 males) participated.

In Years 3 and 4, the children had a mean age of 8 years 6 months (S.D. = 6 months). All participating children spoke English as a first language and were not identified as having special needs. Results of standardised assessments completed as a part of this study suggest that the children were typically developing, with average scores for Word Reading, Passage Reading Accuracy, and Reading Comprehension of 103, 103, and 104, respectively (see Methods for more detail).

Procedure

We followed manual guidelines for all standardised tests. Table 1 reports reliabilities.

Phonological awareness was assessed with two subtests. In the 21 item rhyme test from the Phonological Assessment Battery (Frederickson, Frith, & Reason, 1997), children chose the two rhyming words from three spoken aloud by the experimenter (e.g., *pack*, *lack*, *sag*). In the 24 item Phoneme Deletion Task (Wood, 1999), children repeated a word back to the test administrator without either the first or last phoneme (e.g., *igloo* – *glue* and *party* – *part*, respectively).

Prosodic sensitivity was assessed using the Dina the Diver task (Holliman et al., 2014). Children decide which correctly spoken utterance matches the low-pass filtered utterance. For example, in linguistic stress trials, children chose between ‘Bananaman’ (weak-strong-weak-strong) and ‘Cinderella’ (strong-weak-strong-weak) as a match to a presented

utterance. In intonation trials children decided whether an utterance implied a question or a statement, with a rise or fall in intonation, respectively (e.g., /Teletubbies or \Teletubbies, respectively). Lastly, in syllabic timing trials, children distinguished between utterances of the same duration or of different durations (e.g., Backyardigans versus Backyardigans or Backyaaaaaardigans). The duration effect was established with Praat 4.0.7 and the filtered effect with Sound Forge Audio Studio 9.0. There were 15 items on each subtest¹. Based on prior theorizing (Holliman, 2016) and research (e.g., Holliman et al., 2017), performance was pooled into a global measure of prosodic sensitivity. The measure as a whole had a somewhat low reliability of .63; removal of 8 items increased reliability to .70, which is adequate when assessing novel and complex constructs (e.g., Field, 2013). The task then had a maximum score of 37; 10 of the remaining items tapped stress, 15 intonation and 12 syllable timing².

Vocabulary was assessed with British Picture Vocabulary Scales II (Dunn, Dunn, Whetton, & Burley, 1997). In each trial, children pointed to the picture from a choice of four that best-matched a word spoken aloud.

Morphological awareness was assessed with the Morphology Task (Duncan, Casalis, & Cole, 2009). For each of 18 items, children are asked to modify a word to complete an orally presented partial sentence (e.g., ‘When there is *dust*, it is...’). Completions were all derived forms with no stress shifts (e.g., *dust-dusty*; Fudge, 1984).

Word reading was assessed with the 90 item Word Reading subtest of the British Ability Scales III (Elliot & Smith, 2011).

York Assessment of Reading Comprehension (Snowling et al., 2009) was administered. Children read two passages of increasing difficulty as quickly and accurately as possible. The

¹ Reliabilities for two of the three individual sub-tests were quite low. Reliability for the stress items was .321, for intonation .727 and for timing .346. Given our interest in prosodic sensitivity as a whole, we report on analyses on a combined score.

² The same pattern of results emerges with the score with all items of the prosodic sensitivity task as with the more reliable subset of items.

number of words read accurately was their passage reading accuracy score. To assess reading comprehension, children answered open ended questions probing understanding of the texts. Because of the standardised approach in these tests, we use standard scores in analyses with these two outcomes.

Results

<TABLE 1 HERE>

Table 1 contains descriptive statistics and correlations. Preliminary analyses ensured that data met assumptions for multiple regression, including homogeneity of variance and linearity. There was a single outlier, which was removed from analyses. VIF and tolerance values were in recommended ranges and correlations are all below .66, suggesting no concerns with multicollinearity.

As initial exploration, we conducted a factor analysis with all seven variables, using varimax rotation. There were two factors extracted with eigenvalues of over 1, together accounting for 70.4% of variance. The scree plot also supported two factors. Phonological awareness, vocabulary, prosodic sensitivity loaded on the first and word reading, passage reading accuracy on the second. Interestingly, morphological awareness and reading comprehension loaded on both, though morphological awareness most strongly on the first and reading comprehension on the second. We then examined communalities; these show that up to 67% of the variance in each of the language variables is shared variance, and, on the flip side, up to 55% is unique variance. These results resonate with the moderate correlations between all language variables ($\sim .5$). Together these analyses suggest that there is something shared between all of our language variables, and something unique within each. Given the theoretical predictions of unique effects, we tested these with linear regression analyses.

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We inspected normality, finding normal distributions on all but three measures. Phoneme deletion was negatively skewed. To rectify this, and to produce a single estimate, we created a composite measure combining z-scores for the two phonological measures. Negative and positive skew on word reading and reading comprehension, respectively, was corrected using each of square root and log transformations. These scores were used in correlational and regression analyses, with the same pattern of results emerging with raw scores.

We conducted multiple regression analyses in which all predictor variables (phonological awareness, prosodic sensitivity, vocabulary, and morphological awareness) were entered simultaneously. Separate analyses were conducted with each outcome variable: word reading, passage reading accuracy, and reading comprehension. Table 2 reports on these results. Effectively, values in this table reflect unique effects of each variable following on all others. For example, reported effects of morphological awareness follow on controls for phonological awareness, prosodic sensitivity, and vocabulary.

As shown in the left side of Table 2, neither prosodic sensitivity nor vocabulary made significant unique contributions to any reading measure. Each of morphological awareness and phonological awareness made unique contributions to word reading (7% and 6%, respectively). Further, morphological awareness made a unique contribution to passage reading accuracy and reading comprehension (5% and 11%, respectively).

Further analyses examined whether the unique contributions of each variable on each of passage reading accuracy and reading comprehension remained beyond word reading as well as all the other predictor variables. Analyses with passage reading accuracy tested whether relations are general to accuracy in reading text or specific to reading comprehension. Results are shown to the right in Table 2. The effects of morphological awareness (7%) on reading comprehension, but not on text reading accuracy, remained beyond this additional control.

None of these effects interacted with grade (beta values from $-.090$ to $.172$, $ts < 1.183$ and $ps > .242$), pointing to consistent effects across the two grade groups.

<TABLE 2 NEAR HERE>

Discussion

In a study of typically developing English-speaking children, we evaluated the direct unique effects of each of prosodic sensitivity and morphological awareness measured at 5 and 6 years on word reading and reading comprehension assessed two years later.

Vocabulary and phonological awareness were included as controls. There were unique effects of morphological awareness on word reading, text reading accuracy, and reading comprehension; effects on reading comprehension remained even after controlling for word reading. There were no significant unique effects of prosodic sensitivity on any of our reading outcomes.

The direct effects of morphological awareness on multiple reading outcomes extend prior work, particularly in demonstrating their independence from prosodic sensitivity. Only two prior studies have showed the independence of effects of morphological awareness on word reading from prosodic sensitivity. Both were with children ages 5 and 6 years (Holliman et al., 2014; 2017). We confirm here that these unique effects remain longitudinally for word reading and that they extend to text reading accuracy and reading comprehension, at least for older children. Building on prior studies of word reading (e.g., Holliman et al., 2017) or of measures combining word reading with reading comprehension (Clin et al., 2009), we show that effects of morphological awareness on reading comprehension are separate from those on word reading. These analyses also give us a sense of the size of the unique effects of morphological awareness; its effects on reading comprehension are just as substantial as those of word reading (see Deacon et al., 2014; Kirby et al., 2012 for studies without prosodic sensitivity as a control). Given the widely acknowledged centrality of word reading

in understanding texts, these findings demonstrated the real value in the metalinguistic skill of morphological awareness in children's text comprehension.

We did not uncover unique effects of prosodic sensitivity on either word reading, text reading accuracy or reading comprehension. These findings add one more piece of information to the earlier conflicting results; in two studies with 5- to 6-year-olds, direct effects emerged in one (Holliman et al., 2017), but not the other study (Holliman et al., 2014)³. Together, these studies suggest that prosodic sensitivity might support children's first forays into word reading, with effects ebbing across development (e.g., Holliman et al., 2017). And yet, it seems more likely that prosody might be key in the reading of multi-syllabic words likely encountered by older children (e.g., Holliman et al., 2017). Further still, the skills themselves might diverge over time, as might their contributions to word reading and reading comprehension. In terms of reading comprehension, the null effects of prosodic sensitivity demonstrate the value in testing their uniqueness from morphological awareness, a novel control in our study.

As in all studies, we need to consider limitations. Our prosodic sensitivity task had reasonable reliability given that that it is a novel and complex construct (.7; Field, 2013; Hair, Black, Babin, & Anderson, 2010). Reliability has been a real challenge in prior studies, with alpha levels ranging from .3 to .95, with many around .7. Clearly this could be improved. Further, our tasks did not measure the use of prosodic features as they play out during reading (e.g., Kuhn & Stahl, 2003); these could be assessed alongside prosodic sensitivity and morphological awareness. We think that its worth noting that the non-significant effects of vocabulary on word reading and reading comprehension are consistent with other recent research; morphological awareness might capture a good deal of the

³ We confirmed this pattern here with the more reliable measure of prosodic sensitivity that we identified. Our re-analyses of data from the current study confirm that prosodic sensitivity did not contribute to word reading at Years 1 and 2, following the controls of phonological awareness, vocabulary, age, and morphological awareness.

variance in reading outcomes for older children (e.g., Levesque, Kieffer, & Deacon, 2017). And yet some newer studies are contrasting shared with unique variance between predictors (Kieffer, Petscher, Proctor, & Silverman, 2016); this could be implemented in a study with multiple measures of each construct and an adequate sample size. Such approaches would also enable structural equation modelling, which would reduce the influence of measurement error and permit exploration of indirect paths. Further, given the typicality of performance on the standardised measures of reading, we consider this sample as typically developing. That said, future studies could include measures of socio-economic status.

In terms of theory, our findings of separate and unique effects of morphological awareness on both word reading and reading comprehension broadly support the Reading Systems Framework (Perfetti & Stafura, 2014). We extend this theory by demonstrating uniqueness of these effects from prosodic sensitivity. Interestingly, our non-significant direct effects of prosodic sensitivity on word reading and reading comprehension are consistent with original theorising (Wood et al., 2009), although not with connectionist modelling pointing to specific unique effects of each with word reading (e.g., Arciuli et al., 2010). Our theoretical, and accordingly, analytic approach focuses on unique contributions, an approach validated by communalities and data checking. The analysis that we report on in the manuscript is designed to control for the very likely shared variance between our variables of study, and explore the unique aspects of each component of language. We think that the identification of unique effects has practical value, such that interventions can focus on targeted components of language, rather than language as a whole. And yet, we acknowledge that the language variables under study here are both separable and related; we think that this tension and reality deserves further investigation.

Our findings provide empirical confirmation of the importance of morphological awareness, both for word reading and reading comprehension. We demonstrate the

uniqueness of these impacts from prosodic sensitivity. In sharp contrast, prosodic sensitivity did not contribute uniquely to either word reading or reading comprehension. As a direct effect, morphological awareness might be a proximal focus for intervention (e.g., Bowers, Kirby, & Deacon, 2010), which might not be the case for prosodic sensitivity. We encourage future investigation into the intersection of prosodic and morphological cues, both in word reading and in reading comprehension across reading development.

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Table 1. *Descriptive statistics and reliabilities for all measures, and correlations between them*

Task (Max)	Mean (SD)	α	1	2	3	4	5	6
<u>Years 1 and 2</u>								
Rhyme Awareness (21)	12.94 (3.65)	.92 ^a						
Phoneme Awareness (24)	17.09 (4.95)	.85 ^b						
1. Composite phonological awareness								
2. Prosodic Sensitivity (37)	23.71 (4.98)	.70 ^b	.51	-				
3. Vocabulary (168)	67.84 (11.12)	.93-.94 ^c	.54	.48	-			
4. Morphological Awareness (18)	9.30 (5.08)	.90 ^b	.61	.46	.63	-		
<u>Years 3 and 4</u>								
5. Word Reading (90)	62.23 (9.71)	.97-.99 ^c	.52	.31	.34	.53	-	
6. Passage Reading Accuracy ^d	102.99 (10.30)	.75-.93 ^c	.43	.30	.26	.44	.65	-
7. Reading Comprehension ^d	103.81 (9.19)	.48-.77 ^c	.41	.33	.42	.57	.47	.64

Note: ^a from Frederickson et al. (1997). ^b sample-specific reliability. ^c from manual.

^d Standard score. All correlations > .38 are $p < .001$, > .30 are $p < .01$, and > .25 are $p < .05$

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Table 2

Multiple regression analysis predicting reading outcomes from variables of interest

Predictor Variable	β	ΔR^2	β	ΔR^2
Word Reading				
Age ⁴	.076	.004		
Phonological awareness	.327*	.057*		
Vocabulary	-.103	.005		
Prosodic sensitivity	-.017	.000		
Morphological awareness	.371*	.068*		
Passage Reading Accuracy	No Word Reading Controls		With Word Reading Controls	
Phonological awareness	.260	.036 [†]	.080	.003
Vocabulary	-.126	.009	-.086	.004
Prosodic sensitivity	.060	.004	.077	.004
Morphological awareness	.326*	.053*	.118	.000
Word reading			.554***	.202***
Reading Comprehension	No Word Reading Controls		With Word Reading Controls	
Phonological awareness	.066	.001	-.007	.000
Vocabulary	.069	.001	.085	.004
Prosodic sensitivity	.045	.001	.004	.001
Morphological awareness	.467*	.108*	.383*	.066*
Word reading			.223 [†]	.033 [†]

Note: Each line represents individual contributions after controlling effects of for all other variables.

[†] $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

⁴ We included age as a control in the analyses of word reading and not of passage reading accuracy and reading comprehension, given the use of age adjusted standard scores for the latter two.